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EIGHTEENTH CENTURY TECHNOLOGICAL EFFICIENCY: THE REUSE OF BRAZILIAN SUGAR CHEST WOOD IN PORTUGUESE CABINET MANUFACTURE

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Abstract

We studied decorative Portuguese furniture from the 18th century Clérigos Church in Porto, to identify the woods used, to analyze their possible origin and understand the criteria for wood choice, according to sample location. We identified wood from Acacia sp., Castanea sativa, Couratari sp. and Dalbergia nigra. D. nigra, Acacia sp. and Couratari sp. may have arrived from Brazil, according to their natural distribution and the Portuguese colonial routes; C. sativa was abundant in the North Region of Portugal. In the 18th century, golden metal brass over black furniture was in fashion in Portuguese ecclesiastical cabinet making. Due to its dark colour, Dalbergia nigra was a desirable wood for the exposed structures of ecclesiastical furniture, such as top drawers and top tables. Couratari is a pale wood. Therefore, it was used in the inner structure of the drawers and legs. Acacia wood was also used in internal parts due to its durability. C. sativa was local and extensive; its wood was used in the inner structures, where it could not be seen. Marks were found in the Couratari wood, which indicated that the timber from chest boards employed to carry sugar from Brazil to Portugal was reused. The high silica content of Couratari wood makes it ideal for building "sugar chests".

Keywords: *wood identification; 18th century furniture; cabinet-making; sugar chests.*

Introduction

The 18th century is the most imposing phase of woodwork in Portugal, and church furniture of the epoch, with carved and gilded wood, represents an extraordinary cultural heritage recognised worldwide, which shows how much we still have worthy of preservation and study. The knowledge of the type and density of wood chosen to build a furniture art piece is the most important component for its comprehension and preservation. In this context, the purpose of this research was the historical study of a furniture set belonging to the 18th century Clergy Brotherhood Church [1]. An *arcaz*, an antiphonal lectern, a chest with three drawers and an armchair were the elements of this set.

Clerigos's Church is quite important for Portuguese art history, as it was designed by Nicolau (Nicola) Nasoni (1692-1773), an Italian-born painter and architect. Its exceptional

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tower is one of Porto's architectural *ex-libris*. Before reaching Portugal, Nasoni worked in Italy and Malta, and he played an important role in Northern Portugal by spreading a unique baroque design. His stonework churches display elaborate curves and precise embellishments and he was able to elevate church plans to a high level of creativity. Porto has a unique baroque feeling especially due to Nasoni's work.

A great number of cabinet makers worked to furnish that church between 1732 and 1783. The prosperous clergy brotherhood wanted the best for its sacristy. Several pieces of furniture were produced during those fifty years. The actual *arcaz* we studied has the rhythmic pattern of four bodies with drawers, similar to another arcaz found in the "Colegiada de São Martinho de Cedofeita" in the city of Porto [2]. Its stylish design is of obvious neoclassical influence. The arcaz, which remained *in situ*, was manufactured to keep precious religious clothes embroidered with gold and silver protected. Today, the antiphonal lectern is kept near the principal altar of the church. The lectern was made at the same time, as stated in the epochal documents, and it matches the design of the arcaz, being crafted by the same designer [3]. The chair is older than the previously mentioned pieces, but it could be similar to a set mentioned in the clergy documents [4]. In fact, that chair is clearly of English influence. Indeed, the city of Porto had a rich colony of British people with important wine trade businesses. The commode-chest is identifiable in the historical archives, as it is of a common eighteenth-century Portuguese type [1], and wood identification can help us pinpoint its origin.

No attempt to identify the wood had been conducted previously, although documents of that time used common names to designate the species. For instance, "sugar chest wood" is a typical phrase that indicates that the planks of the chests used to ship sugar from Brazil to Europe were good enough to be reused. What kind of raw material would that be? Only an accurate wood identification can answer that question. For the main body of the arcaz, the wood specified in documents is "jacarandá" or "black wood", which was confirmed by our analysis.

In brief, from the old documents and from wood analysis we could learn that secondary woods were reused, probably when cabinet-makers and carpenters thought they were in good enough condition to stay in the main structure [1]. The outer wood, which was elaborately carved, was selected according to fashion and price [2, 5].

Materials and Methods

A total of 26 wood fragments were taken from a furniture set (Fig. 1) and processed. The set contained an 18^{th} century Portuguese sacristy arcaz, an 18^{th} century sacristy chair, an $18^{th}/19^{th}$ century chest of drawers (image not shown) and an antiphonal lectern.

Sample preparation for Optical Microscopy and Scanning Electron Microscopy analysis

The wood samples were taken as carefully as possible, from hidden and unpainted areas of the furniture with a scalpel (the size of the fragments was 10 - 15 mm long and 0.3 - 0.5 mm wide) and from hidden and difficult to access parts with a Pressler drill [6] (the wood core had approximately the diameter of a toothpick per 5 mm). Because the size and shape of the samples rendered them difficult to cut for histological analysis, they were embedded in London Resin White (LR-White) using the following procedure: dehydration through a graded ethanol series of 25%, 35%, 50%, 70%, 90% to 100% (v/v) at intervals of 10 min. The pieces were then incubated overnight in a graded series of LR White resin and ethanol (ratios: 1:3, 1:2, 1:1, 2:1, 3:1, 1:0) at room temperature. The embedded pieces were polymerised in LR White at 60ºC for 18 hours, in capped vials. Sections (10-15 µm) were cut on a sliding microtome, stained with safranin and permanently mounted with Entellan New (Merck).

The wood cores for scanning electron microscopy (SEM) were softened in distilled water and warmed in a stove at 60 ºC for 4 hours for softer samples and overnight for harder samples.

The cores were sectioned under a binocular microscope with a hand-held razor blade (to safely handle the razor and use both edges, the blade was broken in half).

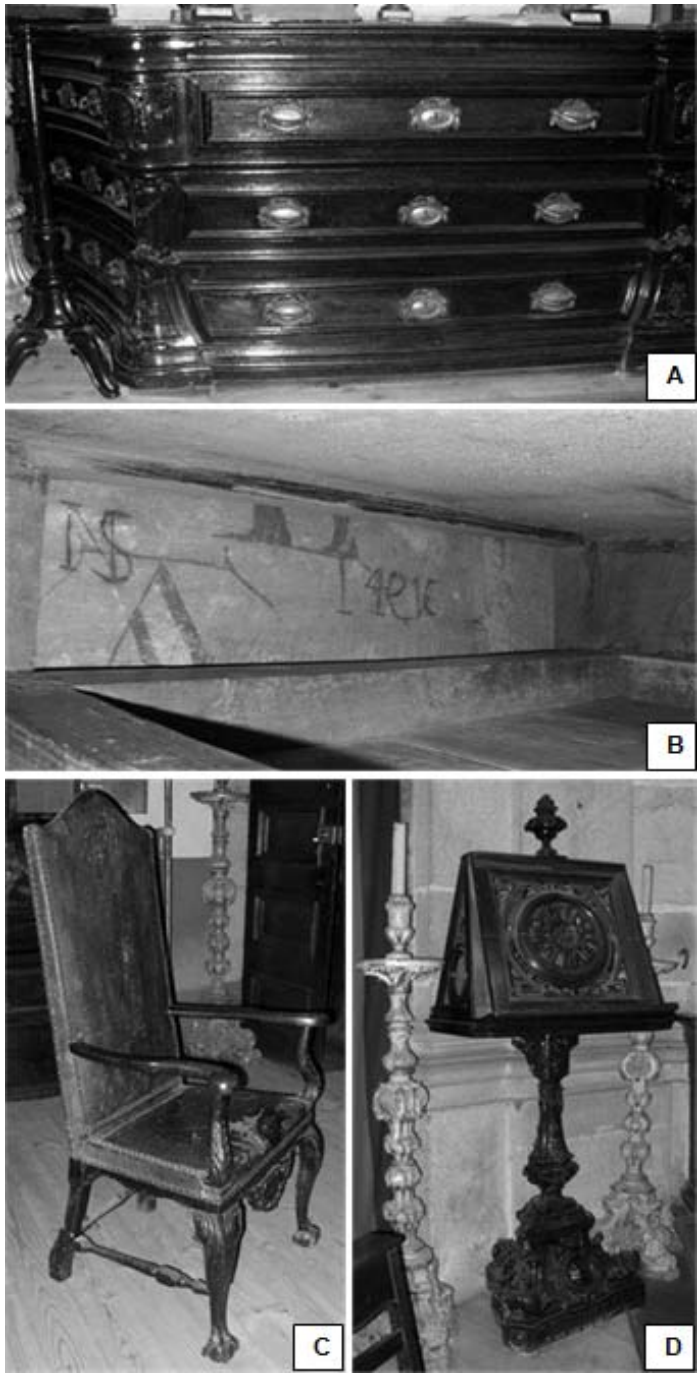

Fig. 1. Furniture set of The Clérigos church. A - 18th century "arcaz". B - "Arcaz" drawer. The numbers and writing in the lateral part of the drawer of the sugar chest are distinct. C - Sacristy armchair. D - 18th century antiphonal lectern.

The first section was transverse. Then, using the orientation of the rays and vessels, the radial and tangential surfaces were easily sectioned. After being air-dried for two days, the blocks were secured to metal mounts, by using a carbon-impregnated adhesive tape. The samples were sputter-coated with gold and imaged, by using a JEOL JSM 6301F microscope. The presence of silica and calcium was measured by an energy dispersive X-ray microanalysis system, Oxford INCA Energy 350, connected to the scanning electron microscope.

Species identification

The tree species were identified with help of INTKEY databases [7, 8], the Wood Identification On-line Databases [9] and the Schweingruber Atlas [10]. The descriptions complied with the recommendations of the IAWA Committee [11].

Results

The arcaz, a unique, large commode, 8.78 m long, displays twelve large drawers and is dated to 1783 (Fig. 1A). The antiphonal lectern, used to hold large and heavy religious books made of parchment, was made in 1783(Fig. 1D). The chest with three drawers is a typical, small Portuguese chest, approximately dated to 1780. It has carved knees and feet and a carved front apron. The two-arm chair of English design influence is covered with plain epochal leather. It was approximately dated circa to 1760 (Fig. 1C).

The use of the Pressler drill helped reduce, or avoid damage to the furniture, during wood sampling. This tool was able to sample a small, solid, compact core of wood from difficult to access parts. After rehydration, the wood core was processed for light microscopy or/and for scanning electron microscope observation.

The furniture parts from which the wood samples were taken and the results of the microscopic identification are summarised in table 1.

Table. 1. Samples from Clérigos Church furniture and wood identification.

Furniture	Furniture part	Identification
Sacristy Arcaz	First top front rail	*Dalbergia nigra*
	First top inside rail	*Castanea sativa*
	First top back rail	*Acacia* sp.
	Inner top front rail	*Castanea sativa*
	Top	*Dalbergia nigra*
	Top (below)	*Dalbergia nigra*
	Drawer bottom	*Couratari sp.*
	Drawer front	*Dalbergia nigra*
	Drawer side	*Couratari* sp.
	Inner front rail	*Couratari* sp.
	Inner side plank (top)	*Castanea sativa*
	Inner side plank (bottom)	*Castanea sativa*
	Bas moulding	*Dalbergia nigra*
	Right corner carving	*Dalbergia nigra*
	Leg	*Couratari* sp.
Sacristy Chest of drawers	Drawer front	*Dalbergia nigra*
	Drawer side	*Couratari* sp.
	Top	*Dalbergia nigra*
	Back Leg	*Dalbergia nigra*
	Side	*Dalbergia nigra*
	Back	*Couratari* sp.
	Inner front rail	*Acacia* sp.
	Front rail	*Dalbergia nigra*
	Apron	*Castanea sativa*
	Drawer side	*Acacia* sp.
	Drawer bottom	*Couratari* sp.
Sacristy chair	Foot	*Couratari* sp.
Antiphonal lectern	Several locations	*Dalbergia nigra*

Below is a brief diagnostic of each species identified. The numbers in brackets correspond to the IAWA codes for each diagnostic characteristic [11].

Acacia sp. (Mimosoideae) presented in figure 2. Distribution: Pantropical [7]

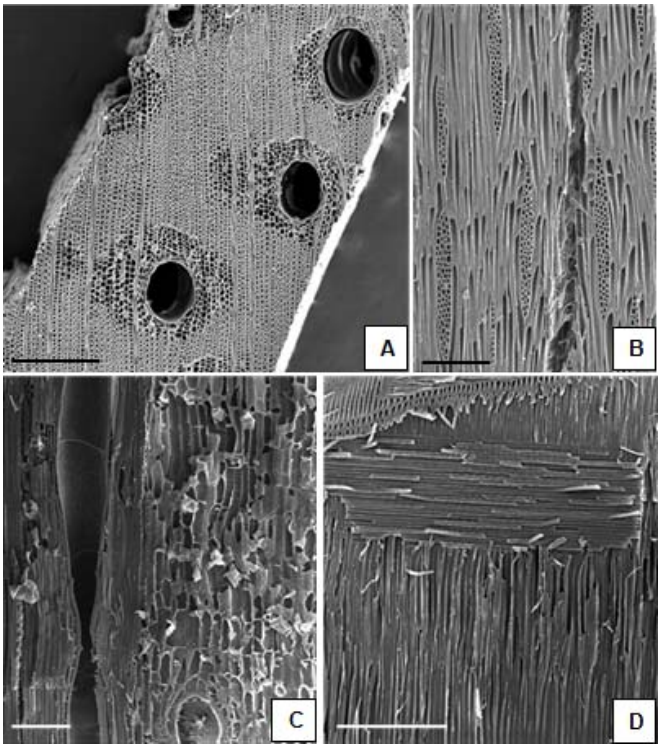

Fig. 2. *Acacia* sp. A - Transverse section (SEM), solitary vessels; note the presence of aliform axial parenchyma. B - Tangential section (SEM), detail of the multiseriate rays. C - Tangential section (SEM) showing a vessel surrounded by a series of axial parenchyma. D - Radial section (SEM) showing a ray profile. Scale bars for A and D = 500 μm, for B and C = 200 μm.

Distinct growth ring boundaries (1). Vessels diffuse (5), solitary more frequent, radial multiples of 2 (10); rounded in transverse section; simple perforation plates (13); circular intervessel pitting, alternate to opposite (21, 22), occasionally with coalescent apertures; vestured pits present (29); reddish-yellow deposits in vessels, less common. Fibres with simple pits (61), septate fibres present (65). Paratracheal axial parenchyma vasicentric (79), lozenge-aliform (81) and confluent (83); axial parenchyma in bands 2-3 cells wide (86); axial parenchyma storied; prismatic crystals in chambered axial parenchyma cells (136, 142). Rays biseriate more frequent, uniseriate less frequent (97); homocellular, all ray cells procumbent (104); deposits in rays present. Silica bodies in ray cells (159, 160). Possible origin, Brazil (186).

Castanea sativa Mill. (Fagaceae) presented in figure 3.

Local name: castanheiro. Distribution: Probably native of south-central Europe, in parts of the Balkan and the Italian peninsulas, extending northwards to Hungary and eastwards to Caucasus; widely cultivated and naturalized in Western Europe [12, 13].

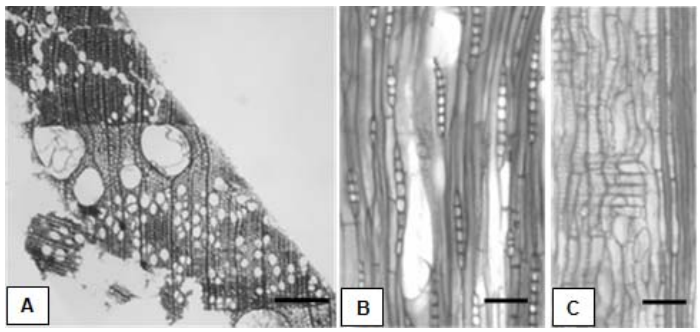

Fig. 3. *Castena sativa*. A - Transverse section showing solitary vessels; note the diagonal pattern. B - Tangential section, all rays are uniseriate. C - Radial section, detail of the vasicentric tracheids. Scale bar for A = 100 μm, for B and C = 50 μm.

Wood ring-porous (3), vessels arranged in diagonal and/or radial pattern (7), solitary vessels (9), rounded in transverse section; simple perforation plates (13); intervessel pits alternate to opposite (21, 22). Fibres with simple to minutely bordered pits (61), septate fibres present (65). Vasicentric tracheids present (60). Diffuse apotracheal axial parenchyma (76); paratracheal axial parenchyma scanty (78). Rays exclusively uniseriate (96); homocellular rays cells procumbent (104). Possible origin, Portugal (165).

Dalbergia nigra (Vell.) Allemao ex Benth. (Fabaceae) presented in figure 4.

Local name: Brazilian Rosewood, Jacaranda, Pau-preto. Distribution: tropical South America [7].

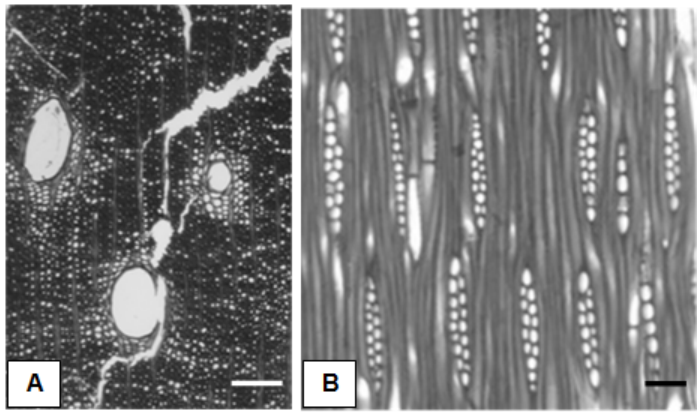

Fig. 4. *Dalbergia nigra*. A - Transversal section showing solitary vessels, diffuse apotracheal axial parenchyma and vasicentric paratracheal axial parenchyma. B - Tangential section showing uniseriate and biseriate rays; note that the rays are storied. Scale bar for A = 100 μm, for B = 50 μm.

Vessels diffuse (5), solitary (9); simple perforation plates (13); intervessel pits alternate (22), vestured (29). Fibres with simple pits (61). Axial parenchyma in marginal bands (89); apotracheal axial parenchyma diffuse (76) and diffuse-in-aggregates (77); paratracheal axial parenchyma vasicentric (79); storied (120). Rays 2–3 – seriate (97); storied (118). Prismatic crystals in axial parenchyma series (136, 142). Ethanol extract fluorescent (210, 214) and water extract negative (205a). Possible origin, Brazil (186).

Couratari sp. (Lecythidaceae) presented in figure 5.

Local name: tauari, tauari branco. Distribution: Amazonia region of tropical South America.

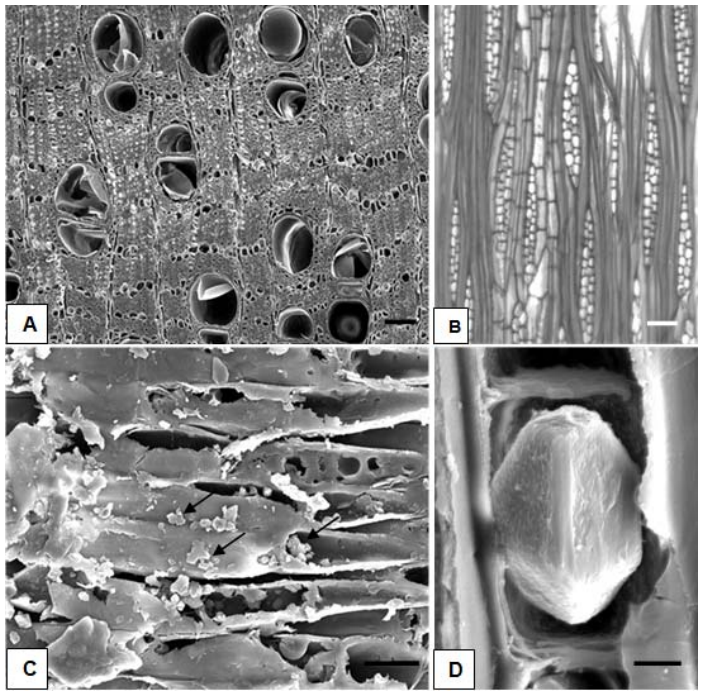

Fig. 5. *Couratari sp.* A - Transverse section (SEM), solitary vessels in multiples of 2, and axial parenchyma in narrow bands. B - Tangential section, rays uni- and biseriate. C - Radial section (SEM); note the silica grains (arrows). D) Tangential section (SEM), detail of prismatic crystals in chambered axial parenchyma cell. Scale bar = 200 μm for A, 100 μm for B, 20 μm for C, 5 μm for D.

Vessels diffuse (5), solitary and in multiples of 2-3 (10); simple perforation plate (13); intervessel pits opposite (21). Fibres with simple pits (61). Axial parenchyma in bands of 1-2 cells wide (86); prismatic crystals of calcium oxalate in chambered axial parenchyma cells (142). Rays 1-2 –seriate, 2-seriate more common (97), silica bodies present in ray cells (159, 160). Possible origin Brazil (186).

Discussion

The results obtained in the identification process of the samples, together with the possible commercial routes that Portugal used with its colonies between the 15th and 18th centuries, show two possible origins of the wood: Brazil and Portugal. In Brazil, the wood came primarily from the Atlantic Forest. In the early decades of territory exploration, European explorers began cutting Atlantic forests and moved inland, when exhausting the tree supply. In the eighteenth century, some explorer teams had already reached the Amazon forest, but it was virtually impossible to transport wood back to the Atlantic coast. This fact excludes the species whose natural distribution is restricted to the Amazon Forest, for instance *Dalbergia spruceana* [14]. The distribution of the identified species is directly related to possible commercial routes used by cargo ships in the 19th century. The only identified species present in Portugal is *Castanea sativa,* which is common in the North of the country.

***Acacia* sp.**

The diagnostic characteristics used to identify *Acacia* wood were diffuse porosity, frequent solitary vessels, presence of vestured pits, fibres with simple pits, vasicentric axial parenchyma in narrow bands 2-3 cells wide and homocellular rays.

Because of its durability, lustrous finish and varied shades, *Acacia* wood is highly appreciated for furniture manufacture.

Castanea sativa

C. sativa is easy to identify by a combination of several features: porous wood rings, vessels distributed in diagonal pattern, exclusively uniseriate rays and the presence of vasicentric tracheids.

This species is common in northern Portugal, where it is mostly used in furniture, probably because of a policy of systematic plantation in northern Portuguese convents [15]. The wood of *C. sativa* was found in the inner parts of the arcaz and in the "saial" of the commode. As it was a readily available and cheap raw material, this wood was found in the hidden parts of the arcaz and commode.

Dalbergia nigra

The identification of *Dalbergia nigra* was based on different features. First was the dark brown to black wood colour and the hardness; the samples of this species were the most difficult ones to remove from furniture. According to Richter and Dallwitz [7] and Miller and Wiemaan [14], *D. nigra* has a medium density between 0.72 gr/cm^3 and 0.96 gr/cm^3. The distribution of axial parenchyma in marginal bands, which are diffuse and vasicentric, corresponds to the genus *Dalbergia*. The storied structure of the rays is also a diagnostic characteristic. The positive result for the ethanol extract and the negative result for the water, correspond to the results of Miller and Wiemaan [14] for *D. nigra.*

The natural geographic distribution of *D.nigra* is useful information that helps in its identification. Species with similar anatomical structure and appearance (as *Dalbergia cearensis, Dalbergia miscolobium, Dalbergia spruceana, Dalbergia granadillo, Dalbergia stevensonnii* and *Dalbergia tucurensis*) were excluded since their natural inland distribution made them most likely not accessible for logging. *Dalbergia nigra* grows in the Brazilian Atlantic Forest from Southern Bahia to Espírito Santo, is also found in the coastal region of São Paulo and in the inland state of Minas Gerais [16]. Therefore, it is reasonable to admit that this distribution made the trees accessible to be used as the major wood source for the European explorers.

Dalbergia nigra was traded for over 300 years [17]. Physical features such as its height (it can reach 38 m), durability, heartwood resistance to fungal and insect attack, and especially the brown to purplish-black colour of its heartwood, made it highly prized for cabinet-making. This was the colour clients wanted, as they wished for a colour contrasting décor. In fact, the altars and images were gilded and painted with striking colours, thus, the furniture should be black with golden handles or with carvings.

The wood of *D. nigra* was used to construct the antiphonal lectern and several parts of the arcaz and the commode-chest (See Table). This wood was found at the top of the arcaz, in the frontal part of the drawers and in the top of the front rail of the chest of drawers. The same wood is also found in the internal structure of the furniture because of its durability and resistance to fungal and insect attacks (e.g., it is found in the first top front rail and the base moulding in the arcaz and the side runner of the commode-chest). The legs of the chest of drawers were also made of *D. nigra.*

In the historical archives of the Clérigos church relating to the arcaz and to the antiphonal lectern, there are references to "black wood", which we believe is "jacaranda", the most appropriate common name for *D. nigra,* according to Camargos [18].

***Couratari* sp.**

The identification of *Couratari* was based on the narrow-banded parenchyma, which produce a net pattern with rays, prismatic crystals in individual chambers of axial parenchyma cells, silica bodies in ray cells, and a diffuse distribution of vessels (See Fig. 5). The woods of *Couratari*, *Cariniana* and *Allantoma* are very similar, and the colour of the wood can help differentiate *Couratari* and the other genera. The woods of *Couratari* are yellow to white-yellow, while *Allantoma* and *Cariniana* are brown to red [19]. The studied samples were all yellow.

Trees of *Couratari* can grow 37 m high, with trunk diameters of 1 to 1.5 m, and its boles are well formed above the stout buttresses. The sapwood is indistinct from the heartwood, which is cream coloured with a pinkish or yellowish tinge. The lustre is low to high, the grain is straight or uniformly interlocked, the texture is medium to coarse and the odour and taste are usually lacking (the odour was reported as fetid in some species). The silica content is reported to be 0.8%. The silica can also be responsible for the resistance to the marine borer attack that is present in some species [20]. *Couratari* is used in general interior construction and carpentry work, boxes and crates, furniture components, veneer, plywood and railroad cross-ties [21].

Couratari wood was found in the arcaz, the commode-chest and the chair. In the arcaz and commode, this wood was used only in the internal parts of the drawers (sides and bottom) and in the inner front rail. In Portugal, the wood boards from sugar chests were reused to make the inner structure of furniture. Such was the case for this arcaz. We can still see the painted marks in one of the dividers between drawers (See Fig. 1B).

Sugarcane cultivation was spread to the eastern Mediterranean by the Arabs in the 12th and 13th centuries. During the next century sugar was imported into Eastern Europe from Cyprus and then from Sicily that became, by the 15th century, a major sugar refiner centre. The Portuguese and the Spanish adopted the Sicilian model and implemented it in their own settlements in the Atlantic Islands. After the discovery of Brazil by the Portuguese in 1500, the economic activity of the territory over 300 years was based first on brazilwood logging, sugarcane agriculture and finally on gold and diamond mining. By the 16th century Brazil became the first great plantation colony and the greatest sugar producer, a model that would later be followed by other European nations in their own Caribbean colonies. Sugar was a very valuable good in Europe, and its production became the main Brazilian colonial produce in the 16th–18th centuries [22]. *Couratari* was one of the woods used to store sugar when it was shipped to Europe. According to a document from 1711 [23], there was a special trade of chests in the Brazilian "engenhos" (factories that squeezed cane into sugar). Those chests were built with 86 nails each and were waterproofed with clay and banana peels. Each chest carried between 500 and 550 kg, and some 37,020 chests were assembled annually. Approximately 98% of the sugar was sent to Lisbon [23]. The sugar would then be sent from Portugal to other European kingdoms. The wood chest had to display on the surface several ink or fire stamps, which identified the weight, the producer and the client. *Couratari*'s impermeability to salty water [20] due to the presence of silica bodies and storage of extractives made it an ideal wood to carry precious merchandise.

We found one mention of an "arcaz" built in 1771 in the same sacristy of Clérigos Church. The inside body of the subsequent 1783 arcaz almost certainly made use of the wood

from the previous version and "sugar chests" woods were afterwards added. Our opinion is based on the lack of any specification in 1783 of the inner structure woods [1].

The chest of drawers that we studied is similar to the one listed in the clergymen inventories [1], and its stylistic features place it in the last thirty years of the eighteenth century. The same *Couratari* wood was found in our analysis in the back and in the inner part of its structure, where *Acacia* was also found, as well as in the drawers. *D. nigra* is the wood of the top, feet, and sides of the commode; its dark colour was a sign of richness, as it was imported from distant colonies and was therefore expensive. Only rich people or institutions could afford this wood. It was, in fact, a sign of luxury [3].

As for the chair (which was in a quite bad condition, as it had been attacked by worms), its back and seat were most probably covered with epochal leather. Now it is thin and worn. As for the general design, this chair is of English inspiration, with claw and ball feet, and it is possibly one of a set of fourteen registered in documents of that church [24].

Conclusions

The use of a Pressler drill helped avoid or reduce the damaging of furniture during wood sampling, and the combination of light microscopy and SEM observations allowed fast and accurate wood identification.

The identification of the woods that were used in the studied furniture, stresses the importance of Brazilian species employed in carpentry and cabinet-making in Portugal during the 18th century. Three species were identified: *Dalbergia nigra*, *Acacia* sp. and *Couratari*. The physical characteristics of each species explain their position in the structure of each object.

Because of its dark colour, its durability and its resistance to insects and fungi, the timber of *D. nigra* was used in the outer parts of the furniture.

Acacia sp. timber is also strong and lustrous and was used in the interior, especially in the arcaz drawers and the commode-chest. From the analysis of the building structure, we consider that this wood was used to support the entire heavy body of the "arcaz".

Castanea sativa, which does not have an attractive colour was not in fashion, was also used in the hidden parts of the furniture. As chestnut wood was local, it was not highly valued at the time, the tropical coloured woods being the most preferred.

The identification of *Couratari* sp. and the marks found in this timber made it possible to establish a relation between the two "arcazes" built in the sacristy of Clérigos Church, one in 1771 and the other in 1783. The use of *Couratari* was not unexpected, as that wood has a high silica content, which confers resistance against the salinity of seawater and makes it a good choice for manufacturing not only sugar chests, but also storage boxes for other merchandise. As it was less expensive than other wood planks, carpenters and cabinet-makers reused it in the inner structures of furniture or in black-painted pieces, as was the case of the studied chair.

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